

## A PUNCH DEVICE FOR A SUBSTRATE HAVING A LARGE BREADTH AND SMALL THICKNESS

### BACKGROUND OF THE INVENTION

#### Field of the Invention:

[0001] This invention relates to electric punching. Specifically, the present invention relates to a punch device for substrates with a large breadth and a small thickness.

#### Description of the Related Art:

[0002] There is a wide use of substrates having a small thickness. In particular, in some fields, such substrates need to have anti-strain intensity, air permeability, or some other characteristics resulting from micro-pores. In current cigarette manufacturing industry, one of the available methods to reducing the quantity of tar that is sucked from a cigarette is to punch micro-pores onto the cigarette and the filter joining paper to reduce the content of tar in the cigarette by enhancing its air permeability. There are two kinds of punching methods currently used for punching the filter joining paper. One is punching on-line and the other is pre-punching. The method of pre-punching is acceptable in producing, which uses static electricity or a laser to pre-punch on the filter joining paper line. However, existing products most often only have one or two rows of micro-pores, which cannot meet the requirements of

air permeability and thus provide low efficiency. There is no device to produce a filter joining paper and filter plug wrap of high air permeability by punching on the substrates having a large breadth and small thickness. In addition, until now, there is no filter plug wrap having a high air permeability that is produced through changing the paper manufacturing process.

[0003] The aspects of the present invention provide a device scheme for punching on the filter joining paper and normal filter plug wrap paper by electric punching. The device can work steadily and the filter plug wrap paper punched by the device can satisfy the requirements of high air permeability.

[0004] Thus, it would be a distinct advantage to have a punch device for substrates having a large breadth and a small thickness. It is an object of the present invention to provide such an apparatus.

#### SUMMARY OF THE INVENTION

[0005] In one aspect, the present invention is a punch device for a substrate having a large breadth and small thickness. The punch device includes a mechanism for winding and unwinding, a correcting control unit, a tension control unit, a hydraulic mechanism, a punch mechanism, a high frequency and high voltage generator, a detecting unit, a controlling means for speed, a pulse frequency and pulse width control, and an user interface. The punch mechanism is composed of at least two or more electrode matrixes. Each electrode matrix is made up of a plurality of electrode bars longitudinally arrayed, which forms an angle  $\alpha$  with the movement direction of the substrate. Each pair of the electrode bars is composed of an anode bar and a cathode bar on either side of the substrate. Each bar is provided with electrode pins in the number of M.

- [0007] Advantageously, the movement direction of the substrate crossing the electrode matrixes is vertically downwards or upwards and the axial direction of the positive and negative electrode-pins is horizontal.
- [0008] Advantageously, the detecting unit comprises a rolling diameter detecting means, a tension detecting means, and an air permeability detecting means for the substrate.
- [0009] Advantageously, the high frequency and high voltage generator generates high power and high frequency voltage with an IQBT tube and a high frequency and high power booster.
- [0010] Advantageously, the controlling means for speed, pulse frequency and pulse width control comprises a single interface for the detecting unit, a computing central processor, an output interface for signals of speed, an electrical pulse frequency and impulse width, and corresponding computer software.
- [0011] Advantageously, the angle  $\alpha$  between the electrode bars and the movement direction of the substrate can be changed by adjusting the position of either end of the electrode bars.
- [0012] Advantageously, the electrode matrix consists of  $N$  ( $1 \leq N \leq 100$ ) sets of electrode bars. Each electrode bar is provided with  $M$  ( $1 \leq M \leq 50$ ) electrode-pins.
- [0013] The principle of the punch device for multi-unit substrate with large breadth and small thickness according to the present invention includes the following.
- [0014] In one aspect, the present invention includes a part for paper feeding having a paper unwinding mechanism, a correcting control unit, a tension control unit, a speed control unit, a rolling diameter detecting means, and a paper winding mechanism. An alternating current speed regulating servo drive control for the paper winding and paper unwinding mechanism, constant tension control, and correcting control are the core of this part. In order to realize punching continuously, steadily, and at high speed, steady

paper feeding should be ensured, and steady paper feeding speed is dependent on the speed, strain and rolling diameter of the paper. The present device detects the rolling diameter, tension and speed of the paper automatically by controlling the computer. Based on the given speed, the device controls the alternating current speed regulator for paper winding and unwinding to a servo drive and controls the speed of the motor for paper winding and unwinding using multi-variable intelligent controlling arithmetic, such that the stability of the paper's longitudinal feeding can be ensured. On the other hand, the device detects the variation of the paper's transversal feeding utilizing a CCD photoelectric multi-color line and border rectified detector that ensures the stability of the paper's transversal feeding by controlling the hydraulic control system through a computer. When paper cuts off, a photoelectric paper cutting detector controls the device to stop jointing paper through the computer.

[0015] In another aspect, the present invention includes a part for punching having a control unit for frequency and power for punching, a high frequency and high voltage generator, a multi-unit punching electrode matrix, a hydraulic control unit, a control computer, a user interface, and an air permeability detecting means. Air permeability of the punched paper depends on the size and density of the holes punched on a unit area. The size of the holes is relative to the pulse width of the high frequency and high voltage, voltage strength and paper feeding speed, while the density of the holes is relative to the pulse frequency of the high frequency high voltage and the paper feeding speed. The device can set air permeability values of various rows of punched holes through the user interface. The control computer then calculates the punching frequency, pulse width, voltage strength based on the setting values and the detected value of the air permeability, and controls the IGBT tube of a power control generator to generate high power and high frequency voltage, and transmits it to the punching electrode matrix after the voltage boosted by a special designed high frequency transformer. The

punching electrode matrix is composed of N pairs of electrode bars, wherein each pair of the electrode bars consists of one above bar and one below bar, and 10~20 electrode-pins made of special materials (e.g., cerium, tungsten) lined up on each electrode bar. Each pair of electrode-pins is aligned with each other and a 0.5~5mm interval is kept between each other. When a high frequency and a high voltage pulse is loaded on the electrode-pins, they discharge to generate an electric spark. The device then breakdowns the substrate to form eyelets on the substrate, thereby achieving the required air permeability. A photoelectric air permeability detector detects the value of air permeability and feeds it back to the control computer, thus realizing a closed loop control of the punching air permeability.

[0016] The present invention includes an electrode elevating mechanism having a control computer and a hydraulic control system. The present device is a multi-unit electronically punching device which has several thousands pairs of electrode-pins for punching. To keep each pair of the electrode-pins aligned quickly and accurately with a interval of 0.5~5mm, the control computer simultaneously controls each pair of electrode-pins aligned quickly and accurately and keeps a default interval between each other by utilizing the hydraulic control system.

[0017] The present invention also includes a correcting control. The device detects the variation of the paper's transversal feeding utilizing a CCD photoelectric multi-color line and border rectified detector which ensures the stability of the paper's transversal feeding by controlling the transversal movement of the paper unwinding mechanism utilizing the hydraulic controlling system controlled by the control computer.

[0018] The present invention also includes a closed loop control of the air permeability. The device utilizes the CCD photoelectric detector to detect the punching air permeability online and in real-time. The air permeability value is then sent to the control computer. The control computer then calculates the punching frequency, pulse width, voltage strength based on the

setting value and the detected value of the air permeability, and controls the IGBT tube of the power control generator to generate high power and high frequency voltage. It then transmits it to the punching electrode matrix after the voltage is boosted by a specially designed high frequency transformer, thus realizing a closed loop control system of the punching air permeability.

[0019] The advantage of the present invention is that a unit area of the substrate to be processed can be punched multiple times when it is passed through the working area. Thus not only a strip in the order of a millimeter can be punched, but also a surface in the order of meter in width, especially in the breadth direction, can be punched evenly. Both the high air permeability of the products and the high uniformity and stability of the punched micro-pores can be achieved by utilizing the present invention. The punching efficiency and the producing effectiveness are increased greatly, and the mass production can be satisfied in enterprises.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the following, the present invention will be described with exemplary embodiments accompanying the attached drawings, but the present invention should not be limited to the particular embodiments.

[0021] Figure 1 shows a functional block diagram of an exemplary device in accordance with the present invention;

[0022] Figure 2 shows a structural diagram of an exemplary device in accordance with the present invention;

[0023] Figure 3 shows a longitudinal profile drawing of the electrode bars in accordance with the present invention;

[0024] Figure 4 shows a structural diagram of an exemplary electrode matrix in accordance with the present invention;

[0025] Figure 5 shows a flow chart of the punching control software in accordance with the present invention; and

[0026] Figure 6 shows a block diagram of the paper feeding system in accordance with the present invention.

#### DESCRIPTION OF THE INVENTION

[0027] The following is a description of the reference numbers for the components illustrated in FIGs. 1-6.

- 1-punching unit
- 2-stairs
- 3-base
- 4-paper winding unit
- 5-paper unwinding unit
- 6-diameter sensor
- 7-correcting unit
- 8-scanner
- 9-operating panel
- 10-electrode bar
- 11-hydraulic system
- 12-adjusting roller
- 13-unwinding roller
- 14-adjusting roller
- 15-strain roller
- 16-paper unwinding axis
- 17-paper winding axis
- 18-air-in fan
- 19-exhaust fan
- 20-direction leading roller

21-air pipe  
22-fixed pedestal  
23-direction leading roller  
24-direction leading roller  
25-adjustable pedestal  
26-electrode-pins  
27-lock bolt  
28-connecting bolt  
29-sliding bearing  
30-yew paper

[0028] In the three-unit punch device for a substrate having a large breadth and a small thickness, a paper winding and paper unwinding mechanism includes an active paper winding unit (4), an active paper unwinding unit (5), a paper unwinding axis (16), and a paper winding axis (17), which is located at two ends of the device. It includes a part for paper feeding combined with an adjusting roller (12), an unwinding roller (13), an adjusting roller (14), a strain roller (15), and a direction-leading roller (20). The part for punching comprises three punching units, wherein each unit consists of an air-in fan (18), an exhaust fan (19), a direction leading roller (20), a fixed pedestal (22), a direction leading roller (23), a direction leading roller (24), an adjustable pedestal (25), an electrode bar (10), an electrode-pins (26), a lock bolt (27), a connecting bolt (28), and a sliding bearing (29). Each punching unit has 40 pairs of electrode bars. Each bar has 12 electrode-pins made of cerium or tungsten. The electrode bars are arranged longitudinally, and the angle between the perpendicular direction and the bars can be adjusted through the lock bolt (27) and the connecting bolt (28). All of the three punching units are fixed on the base (3) of the device. The high frequency and high voltage generator is composed of an IQBT tube and a high frequency and high voltage booster. The computer controlling unit for speed, electrical pulse frequency and impulse width control comprises a signal interface of the

detection mechanism, a computing central processor (S7-300), an output interface for speed, an electrical pulse frequency and impulse width signal, and software embedded in the computing central processor as illustrated in Figure 5. The device is also configured with a hydraulic system to control the interval between the anode and the cathode electrodes. The components and circuits adopted in the detecting unit are existing technologies in the prior art.

[0029] Thus, the present invention has been described herein with reference to a particular embodiment for a particular application. Those having ordinary skill in the art and access to the present teachings will recognize additional modifications, applications and embodiments within the scope thereof.

[0030] It is therefore intended by the appended claims to cover any and all such applications, modifications and embodiments within the scope of the present invention.